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MICROBATHYMETRIC SURVEY

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By

Earl E. Hayes

Reference No. 64 - 13

March 1964

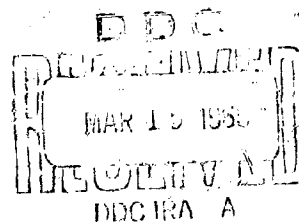
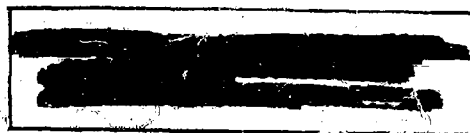
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REPORT
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WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts

PROJECT ARTEMIS

Reference No. 64-13

Microbathymetric Survey

By
Earl E. Hays

Submitted to Office of Naval Research
Under Contract Nonr-2866(00) (NR-287-004)

March 1964

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ABSTRACT

A bathymetric survey was made in a limited area southwest of Bermuda. Precise depth measurements were made by using the Inverted Echo Sounder, an instrument that measures total water depth while placed a short distance above the bottom.

The position of the Inverted Echo Sounder was determined by acoustic travel times from it to certain fixed locations. A plot of the successful tracks made is given.

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INTRODUCTION

In echo sounding from surface ships the relative direction of the area returning the first echo is only determined within the angular beam of the transducer. The approximate area insonified is found by multiplying the beam angle in steradians by the squared water depth. Variations in depth over the insonified area result in complicated echoes and, in general, ambiguity for the depth directly beneath the ship. This ambiguity is reduced by employing transducers with very narrow beams and suitable equipment to compensate for the rolling and pitching of the ship.

Another approach is to position a transducer near the bottom, simultaneously measuring its height above the bottom and its depth beneath the surface by sending and receiving acoustic pulses with it. The angular resolution of the transducer is unimportant for the essentially flat sea surface, and the details of the bottom that can be measured even with an omnidirectional transducer depend only upon the safe working height above the bottom (Figure 1). The new problem is the determination of the instrument's position.

During March and April 1961, USS PRESERVER (ARS-8) was employed in making such a bathymetric survey on Plantagenet Bank. Scientists from Woods Hole Oceanographic Institution, Hudson Laboratories and the U. S. Naval Oceanographic Office formed the scientific complement for the survey, collecting data aboard the ship and analyzing it ashore.

METHOD OF SURVEY

An instrument called the Inverted Echo Sounder (IES) (Dow and Stillman, 1961) was positioned near the bottom on a single conductor shielded wire. This instrument sent out pulses and received echoes from the surface and bottom and the travel times were recorded aboard ship on Precision Graphic Recorders (PGR) (Knott and Witzell, 1960). An additional pinger was attached to the IES and the signals from it were received by hydrophone modules fixed near the bottom as well as by the IES receiving system. These hydrophone signals were transmitted by cables to Argus Tower and relayed back to the ship by radio where they were recorded on PGRs.

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The travel times of these signals gave the distance of the instrument from the fixed hydrophones and the intersections of the corresponding range circles fixed the instrument's position. The radial distance of the instrument from the ship was found by measuring the travel time for an acoustic signal from the IES to the ship and combining this with the depth of the IES. This radial distance and the ship's position gives another circle for the location of the instrument. Total depth of water is then plotted against instrument's position to give a bathymetric chart. Some details of this system and the calculations are given below.

INVERTED ECHO SOUNDER

As the Inverted Echo Sounder has been described (Dow, 1961), only a brief description is given here.

The unit is battery powered and emits very short pulses of 12 kc/s once per second. The main lobe is pointed upwards at the water surface. The unit is connected to the recorders aboard the ship by a shielded single conductor cable. Suitable limiters and amplifiers permit the detection of the outgoing pulse and also the echoes returning from the surface and the bottom. From the Inverted Echo Sounder three signals are obtained: the outgoing pulse, the surface echo, and the bottom echo. A sample record is shown in Figure 2. This shows the record received as the instrument was lowered to the bottom and maintained near it. (The dark horizontal lines are at 20-fathom intervals, the lighter lines are at 5-fathom intervals.) The total depth is somewhat over 400 fathoms the first crossing of the direct and surface signals occurred when the instrument was 400 fathoms deep. The bottom return became visible when the instrument was about 50 fathoms above the bottom in this case. This record was taken in seas of 10 to 15 feet and the rolling of the ship is clearly seen in the record. It can be seen that this effect cancels out in the actual depth measurement.

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RADIO LINK

The radio link was a 14-channel FM telemetering system supplied by Hudson Laboratories that operated near 150 megacycles. The band-pass of each channel was 1.7 kilocycles which was not suitable for the 2-kilocycle navigation signal. Consequently the navigation signals from the modules were amplified, filtered, and then detected before being put into the radio system proper on Argus Island. Aboard PRESERVER, the signals from the modules went directly into the Precision Graphic Recorders.

NAVIGATION SOUND SOURCES

The navigation sound sources mounted on the IES were supplied by U. S. Navy Underwater Sound Laboratory. They were magnetostriction types with resonant frequency at 2 kc/s and an output level of 72 db re one dyne/cm². The repetition rate was a nominal one per 10 seconds but varied with temperature enough to warrant modification. This was done in the field by using a Hayden Timer mounted in an external case.

The 2 kc/s navigation signal as received acoustically by the IES contained enough energy in the bandwidth of the IES to be seen easily on the recorder. However, the narrow bandwidth of the IES eliminated the possibility of separating the IES and outgoing navigation signals as received up the wire on the ship. The original plan was to display the outgoing and received navigation signals on the same recorder for travel time measurements. This was possible for very strong navigation signals from the acoustic-radio links, but for weak ones the combined noise background of the IES and navigation system overrode the signal. As a result, weak signals were displayed alone on a PGR record with suitable time references to enable us to measure the travel times. The use of the Hayden timer on the navigation source also gave better correlation of the received navigation signals and made them easier to identify. Figure 3, is an example of the combined IES outgoing pulses and received navigation signals. An extra signal appears 0.15 seconds after the direct arrival. This was a mechanical click in the timing mechanism. Figure 4 shows the received navigation signal with and without good time control. It can be seen by comparing the

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two records that a weak signal can be used effectively when good time control is maintained and the same signal with equivalent background noise would be difficult to use without it. The actual recording of the top example (poor time control) was made when the IES was very near the module. In fact, a record of the 12 kilocycle/sec echo sounder is seen in spite of the unfavorable filtering characteristics of the system for that frequency.

RECORDING METHODS

Two two-channel PGR's were used to record the navigation data. A time signal from a Times-Facsimile chronometer was put into the PGR's for time correlation.

One of the channels of a two-channel PGR was used to record the direct acoustic signal from the IES to the ship's hull mounted transducer (EDO). This is shown in Figure 5, which also shows the IES-to bottom-to ship signal. The IES signal from the wire was put on this channel to facilitate measurements of travel time.

SHIP'S NAVIGATION

Raydist equipment was installed and used for ship navigation. Unfortunately in this period, March-April 1961, many difficulties were experienced with the Raydist system and we were not able to take advantage of its capabilities during many runs. In principle, reception on one module, ship's positions, and the radial distances of the IES from the ship should be sufficient to define the track of the instrument on a run; the ambiguity of two being eliminated by relative position of the instrument to the ship, knowing the track of the ship and the amount of wire out. In practice this method was only used when it gave results that agreed with navigation from two or more modules for part of the same run.

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OPERATION AT SEA

Three PGR's (one single-channel, two dual-channel), a winch, a radio receiver, and auxiliary equipment were placed aboard PRESERVER. The single-channel PGR was used primarily as the depth measuring recorder and the dual-channel ones for navigation purposes. We normally operated with four people, one on the depth PGR in communication with the winch operator, and two on the navigation PGR's. In addition we had a person on Argus Island to make any necessary changes there.

We chose courses based on wind and sea, trying whenever possible to move down slope during the lowering. The ship maneuvered into starting position, held position until the IES was near the bottom, and then moved along the desired course. Speeds of advance averaged about three quarters of a knot. We moved across the area of interest and then returned to start another run.

CALCULATIONS AND DISCUSSION OF RESULTS

The geometry of the acoustic measurements is shown in Figure 6. Measurements of travel time must be related to distance by use of the average sound velocity for each particular path. Using a sound velocity profile made in the area on 7 February 1961 from CHAIN, we set up a program on the RECOMP II computer to choose the average sound velocity between any two depths, including surface bounce paths. These average velocities were used in all calculations of distances discussed in this paper. The sound velocity profile is shown in Figure 7.

Travel times for water depth (height above bottom, depth of instrument) were read on a half-minute schedule from the records. Similarly travel times for the acoustic navigation were read on a two-minute schedule and the IES-to-EDO travel time was read on a two-minute schedule. This information was then put into the computer which performed the following calculations for measurements all taken at the same time: It calculated depth of instrument and total water depth; then taking depth of instrument and depth of module, it calculated path length for a direct path or surface bounce path to the module, and also the length of the IES-EDO path. Then

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using the equations shown in Figure 6, the radial distances of the instrument from the modules and ship were calculated.

For each run, the track of the ship was plotted according to best navigation data available. Arcs for the distances from the modules and ship were then swung and the best instrument track picked from the intersections. Depths for these fixes were plotted and interpolation used to plot depths measured in between navigation fixes.

In some cases four circles could be used which gave well defined fixes. At the other extreme, only the ranges from the ship and one module were available. The latter type were only used when the run also included some fixes from at least two modules which fit with the ship's single module fix. The other requirement for this measurement was that the track of the ship as plotted from Raydist appear reasonable with no sudden jumps or other erratic behavior.

The final plot is shown in Figure 8. The error in depth measurement can be considered less than one-half fathom, although this is meaningless without consideration of the navigation error.

The average error in navigation can be taken as about fifty yards or less with an extreme error of one hundred-fifty yards. This is not based on our ability to measure travel times but upon the author's judgment after doing all the plotting and the picking of the best point for each set of intersections. Much of the time, surface bounce paths were the only ones available for navigation. When the horizontal range is small compared to total path length, the measurement is sensitive to small changes in path length. The sea state had a strong influence on our ability to use this path, because of roughness of the surface, increased sea noise, and increased ship noise. The effect of topography on the direct paths is shown in Figure 3, in which the navigation signal via the module appears loud and clear and then rather rapidly disappears. (There is a gap in the signal which was due to radio problems.)

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ACKNOWLEDGMENTS

The great help and cooperation of ARS-8 USS PRESERVER, officers and crew, was one of the bright spots of the survey. Too many other people assisted to be listed individually; Tudor Hill Laboratory, Hudson Laboratories, U. S. Navy Oceanographic Office, U. S. Navy Underwater Sound Laboratory and the Office of Naval Research were all helpful in the project.

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- Figure 2. Typical Inverted Echo Sounding Recording.
- Figure 3. Inverted Echo Sounder and Navigation Signal.
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- Figure 6. Geometry of Navigation for Inverted Echo Sounder.
- Figure 7. Sound Velocity Profile used to Calculate Distance from Travel Time.
- Figure 8. Final Plot of Micro Survey.

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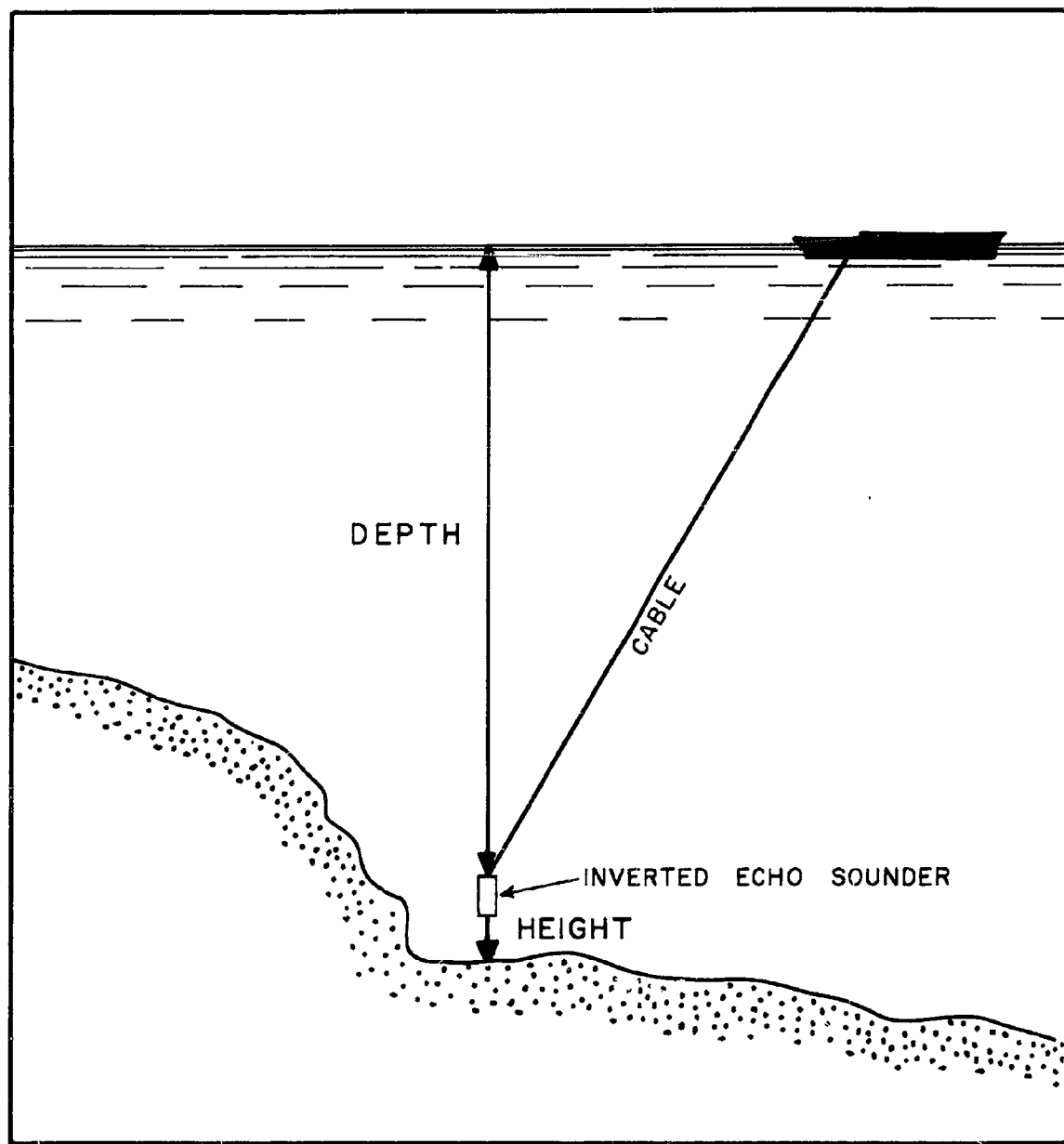


Figure 1. Inverted Echo Sounder Use for Bathymetric Survey.

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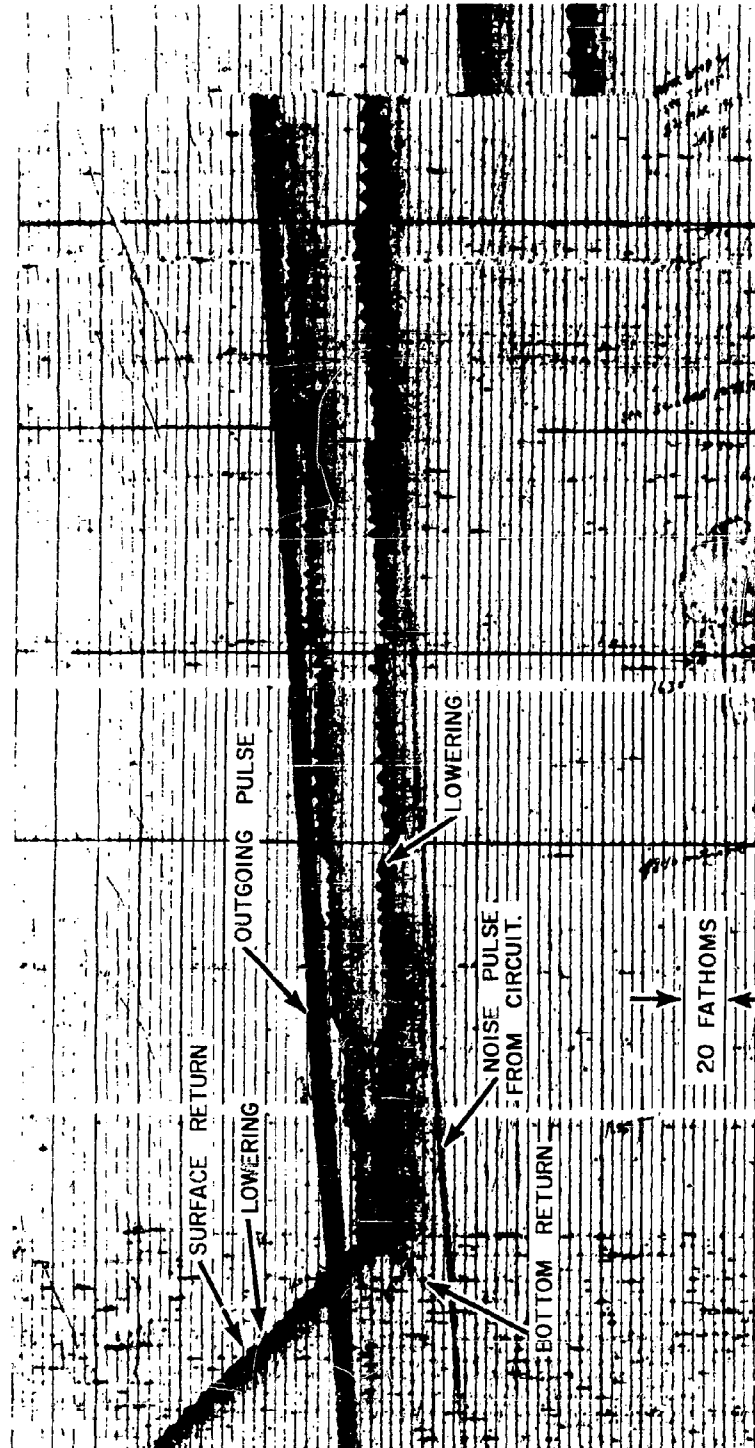


Figure 2. Typical Inverted Echo Sounding Recording.

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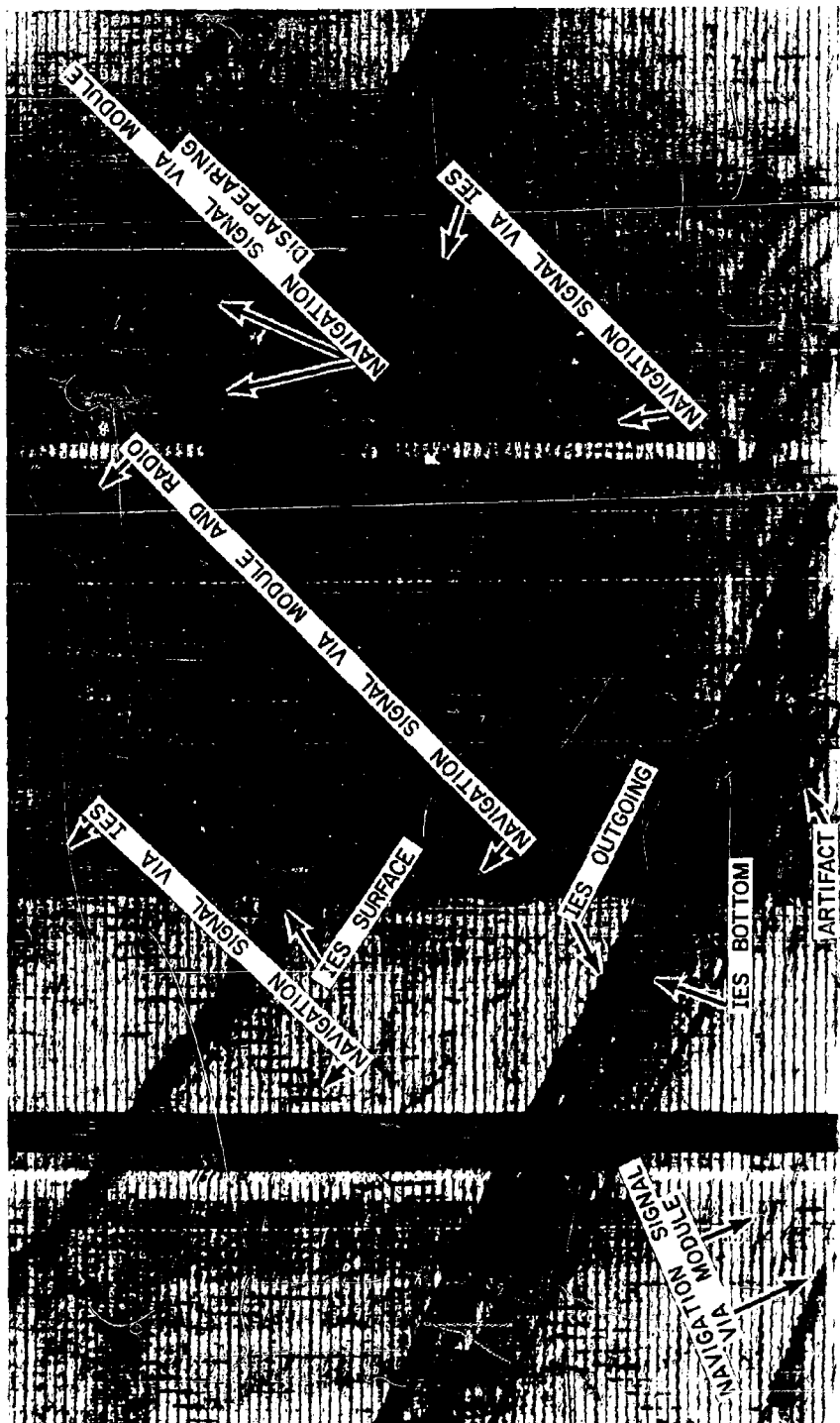


Figure 3. Inverted Echo Sounder and Navigation Signal.

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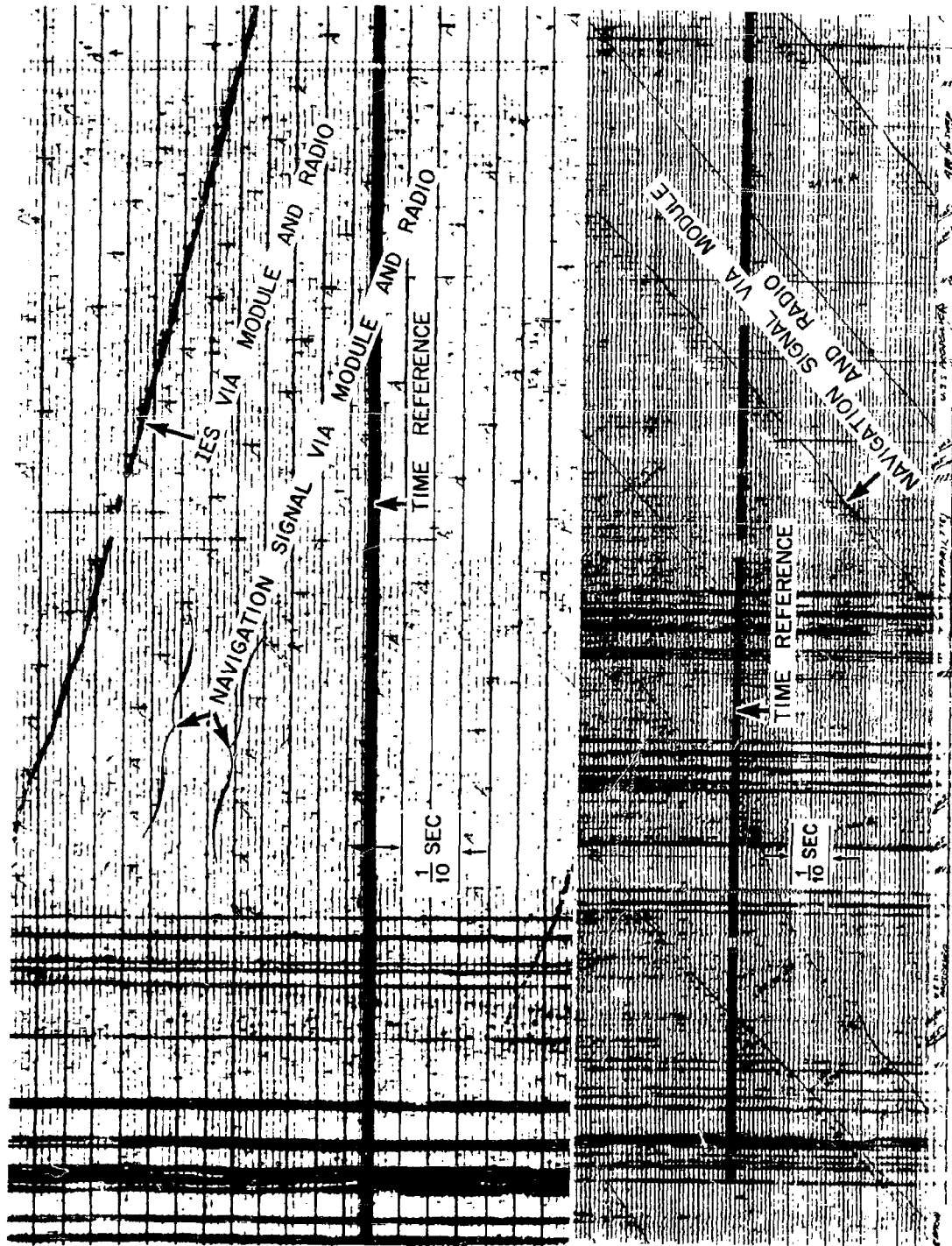


Figure 4. Navigation Signal with and without Good Time Control.

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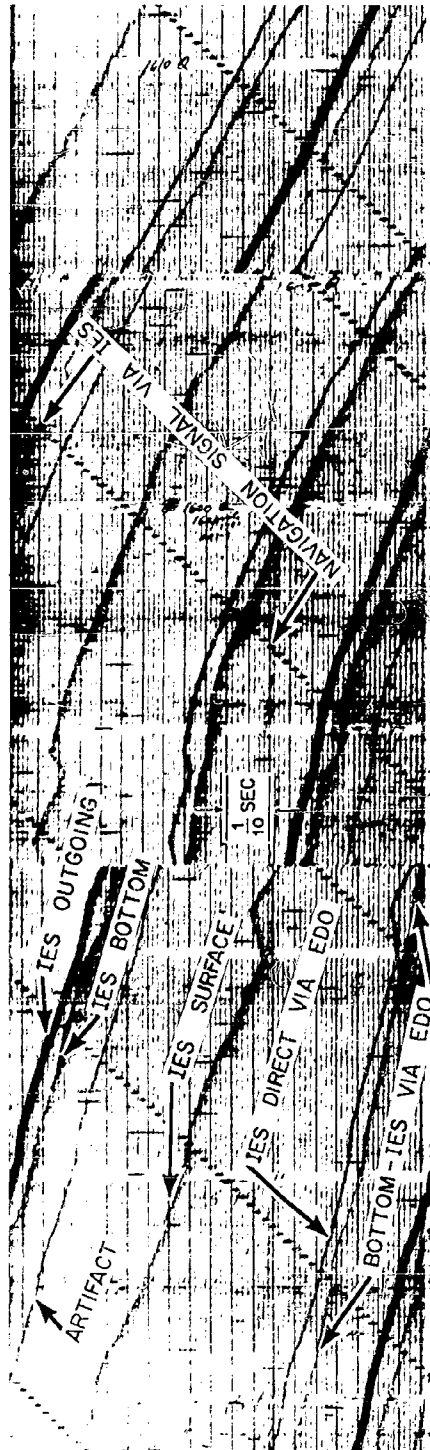


Figure 5. Inverted Echo Sounder Record combined with Signal
Picked up by Ship's EDO.

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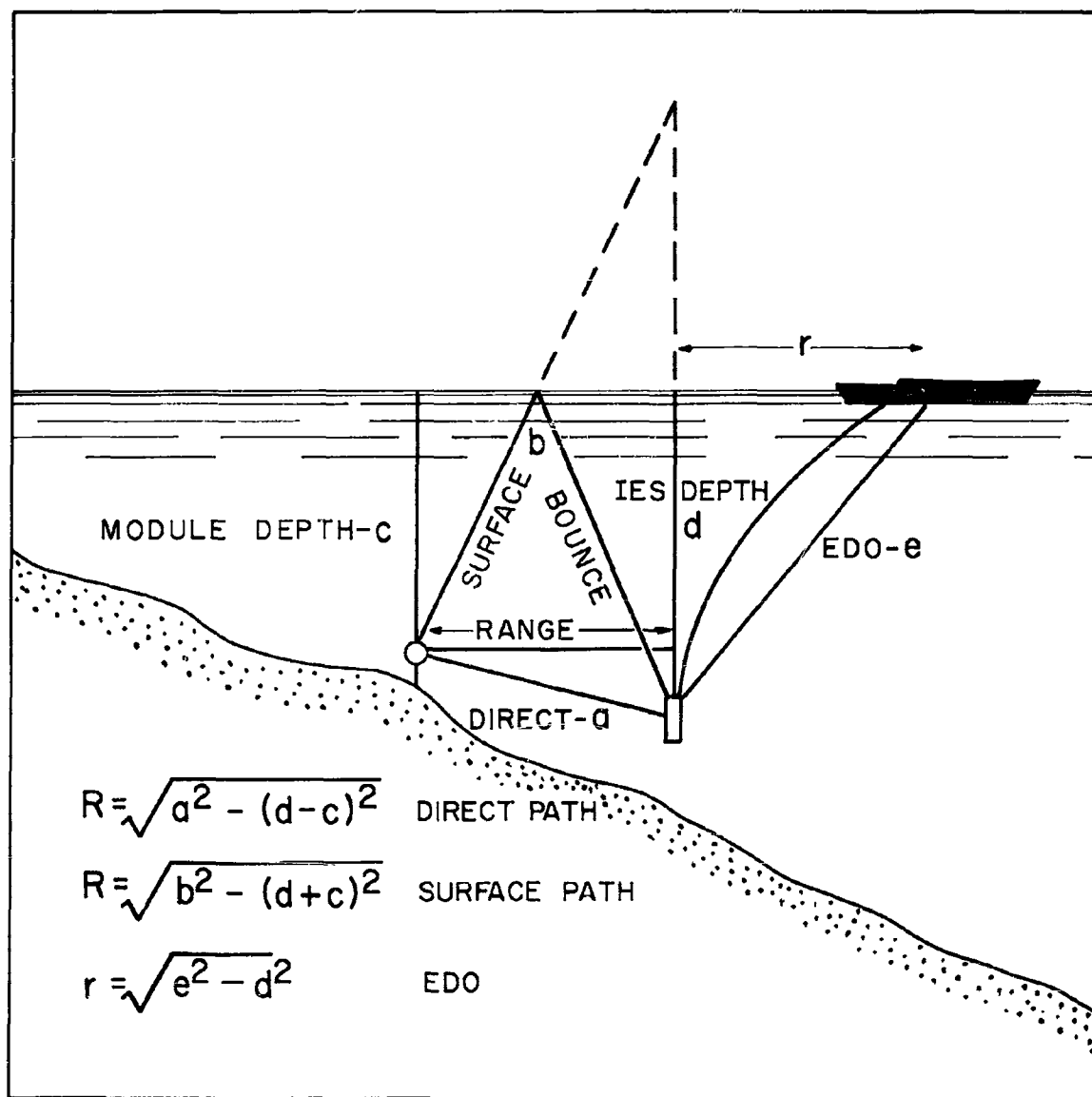


Figure 6. Geometry of Navigation for Inverted Echo Sounder.

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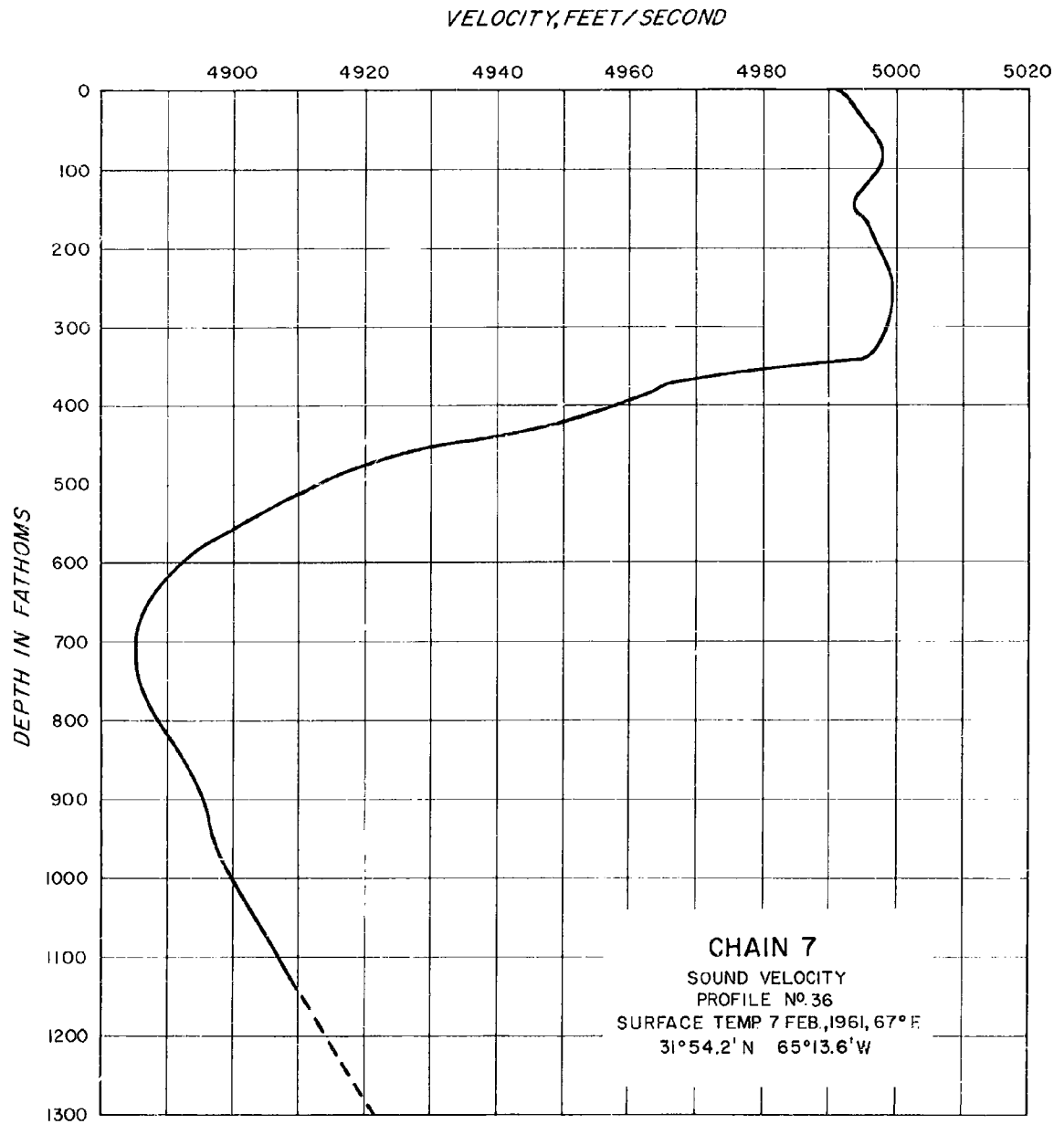


Figure 7. Sound Velocity Profile used to Calculate Distance from Travel Time.

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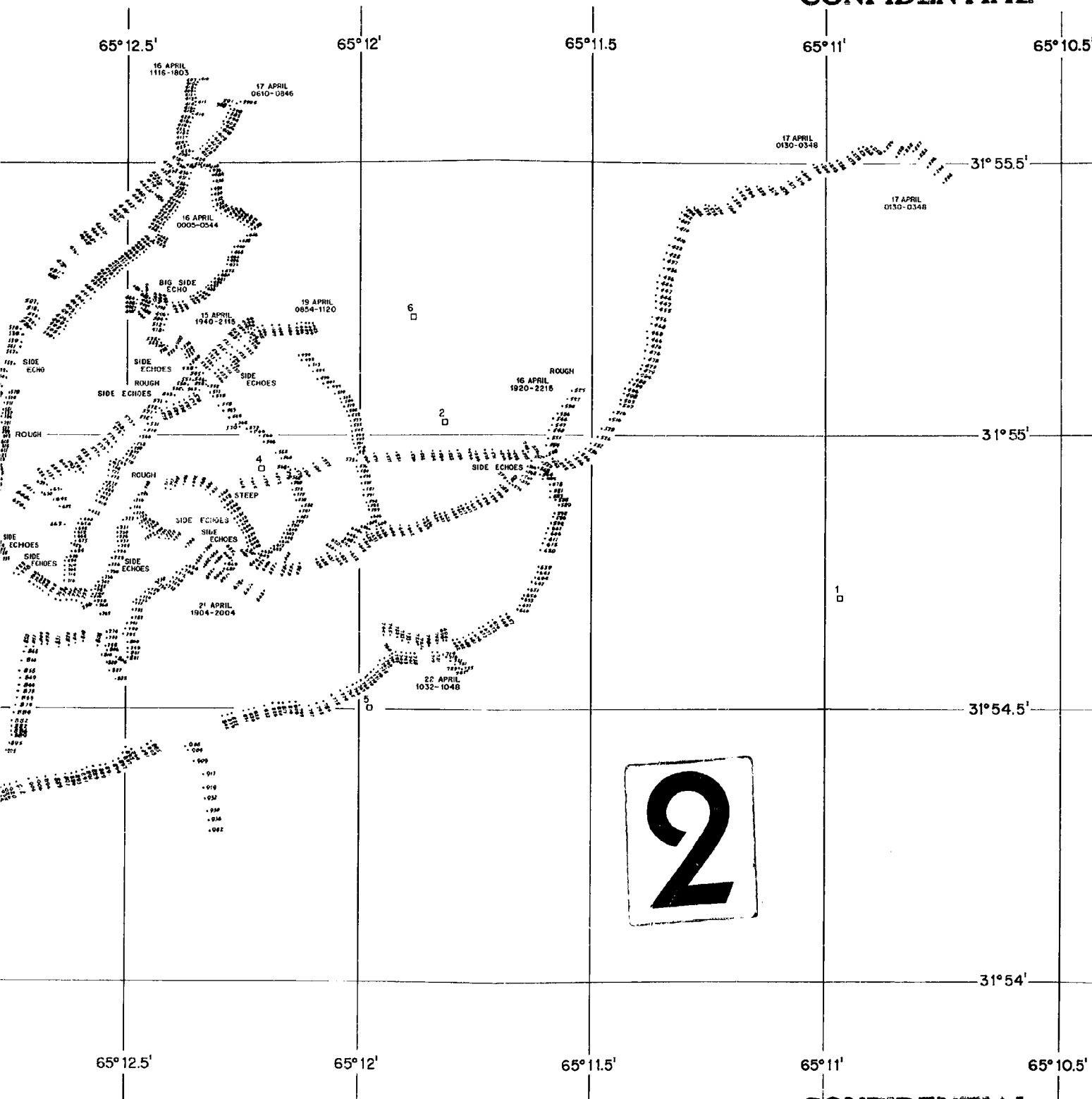


Figure 8. Final Plot of Micro Survey.

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